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The "Great" Magnetic Storms, 1875 to 1903, and their association with Sun-spots, as recorded at the Royal Observatory, Greenwich. By E. Walter Maunder.

(*Communicated by the Astronomer-Royal.*)

In a paper "On the Relation between Magnetic Disturbance and the Period of Solar Spot Frequency," communicated by Mr. William Ellis to the Royal Astronomical Society in 1899, and appearing in the *Monthly Notices*, vol. lx. No. 2, pp. 142–157, Mr. Ellis has classified magnetic movement or disturbance in the following manner, Class I. including all days free from magnetic irregularity, and showing only the ordinary diurnal movement :—

Class.	Degree of Disturbance.	Greatest recorded Magnetic Movement. Declination.	Greatest recorded Magnetic Movement. Horizontal Force c.g.s. value $\times 10^5$.
I.	None	No magnetic irregularity in either element	
II.	Minor	Less than 10′	Less than 50
III.	Moderate	Greater than 10′ Less than 30′	Greater than 50 Less than 150
IV.	Active	Greater than 30′ Less than 60′	Greater than 150 Less than 300
V.	Great	Greater than 60′	Greater than 300.

Adopting the same classification, there were nineteen "great" storms in the twenty-nine years from 1875 January 1 to 1903 December 31. The extreme amplitude of the movements in declination exceeded one degree in all these cases but two. In these two cases it exceeded 55′: but as the movement in horizontal force exceeded 350 on the c.g.s. scale, they have also been ranked as "great" storms, in accordance with Mr. Ellis's definition. The nineteen are thus distinctly the most important "storms" of the entire period of twenty-nine years.

All the nineteen without exception took place when there was present on the Sun a group of spots with projected area of over 1000 millionths of the area of the visible disc; *or* when a group, at one time very large, had returned in a diminished form to the central meridian.

With one exception—No. 18—all the storms began with an exceedingly characteristic movement of the magnets, generally only moderate in amount, but distinguished by its suddenness. This appeared simultaneously in the registers of declination, horizontal force, vertical force, and earth currents, the remarkable feature of the movement being its instantaneousness. This characteristic movement is referred to in Tables I. and II. by the word "sharp" in the column "Character of Beginning." Taking the time of this swift characteristic movement as that of the commencement of the storm, it would appear that these

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nineteen storms did not begin indifferently when a great spot was anywhere on the Sun's disc, but that the most important group visible always lay within a certain region, the position of which, relative to the central meridian of the Sun, was as follows :—

			D.	H.
Extreme easterly position,	19° E. ;	in time	1	11
,, westerly ,,	47° W.	,,	3	14
Mean ,,	14° W.	,,	1	2

The greatest of these nineteen storms were the following :—

Storms 4 *and* 5.—These occurred in a disturbed period lasting from 1882 April 13 to April 24; *i.e.* synchronous with the passage of Spot-group 729, which was visible April 13 to April 25.

Storm 4 was synchronous with a sudden outburst in Group 726 and a smaller outburst in Group 729.

Storm 5 with Group 729 at the normal position, *i.e.* one day past the central meridian.

Storm 7.—A very intense and long-continued disturbance, lasting in all from 1882 November 11 to November 26, synchronising with Group 885—the largest group of the cycle—in its entire passage across the visible disc, viz. from November 12 to November 25. The storm was the most violent of any from the beginning of 1875 up to the time of Storm 19.

Storm 9.—Synchronous with Group 2421, the greatest spot-group of the entire twenty-nine years.

Storm 10.—Synchronous with the return of the last-named group, the disturbance lasting during its entire passage across the disc—1892 March 4 to 17. A very long-continued rather than a violent disturbance.

Group 2421 at its return in 1892 March was numbered Group 2440.

Storm 14.—Disturbance lasted from 1894 February 20 to March 1. Synchronous with the passage across the disc of Group 3412, from February 16 to March 1.

Storm 19.—The greatest storm of the nineteen as regards the magnitude of the movements, but by no means the most long-continued.

The connection between the magnetic "storm" and a great sun-spot was especially clear in the cases of the first six storms noted above. The spots were amongst the most remarkable even of the "nineteen largest" groups, and the magnets were disturbed during nearly the whole time of the passage of the spots across the disc, the disturbance becoming a "great" storm near the time of central transit.

In five cases out of the 19 two considerable groups were on the disc, and it is therefore uncertain which should be associated with the storm. In the case of *Storms* 12 and 13 one of the two groups (Group 2583) was near the central meridian at the time of the beginning of both the storms. The other group (Group 2581)

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seen during Storm 12 was not seen during Storm 13. Group 2581 is, therefore, probably to be associated rather with the "active" disturbance four days earlier, when it likewise had just passed the central meridian. This "active" disturbance is therefore associated with it in Table II.

Four points appear clear from the tables:—

1. There is a real connection between large Sun-spots and great magnetic storms. This is shown (*a*) by the fact that in every case a "great" storm was synchronous with the passage of a large spot or with its return; (*b*) by the correspondence of the very greatest storms to the time of visibility of the very greatest spots; (*c*) by the fact that there were no considerable storms in the interval between the two great spot-groups of 1898 September 3–15 and 1903 October 4–18. The appearance after an interval of more than five years of a "very large" group of spots was answered by a magnetic disturbance greater than any which had occurred in the interval.

2. There is a real, but only rough, connection between the size of the spot and the intensity of the storm. This is shown by the correspondence of seven out of the nineteen greatest storms to seven out of the nineteen greatest spots in a period of over twenty-nine years. The proportion of correspondences in so long a period is far too high to be due to accident. Of the nineteen spot-groups shown in Table II. the nine largest all synchronised with a "great" or "active" storm.

3. The area of the spot-group is not by any means an exact index of the degree or intensity of the magnetic disturbance. This is shown by the fact that the nineteen largest sun-spots corresponded in time to magnetic disturbances as follows:—

To "great"	7
" "active"	7
" "moderate"	2
" "minor"	2
" "none"	1
	19

4. The "great" storms did not begin indifferently at any time of the passage of a great spot across the disc of the Sun, but during the period of five days beginning thirty-four hours before the centre of the spot-group reached the central meridian, and ending eighty-six hours after that time, the mean time being twenty-six hours after the spot reached the central line.

At the same time, as mentioned above, in some of the greatest storms a distinct disturbance began with the entrance of the group on the disc and lasted until its disappearance at the west limb. In these cases, however, a great storm of an altogether distinct character began with a typical sharp movement after the spot had reached the central region of the disc.

Details of the "storms" and spot-groups follow.

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TABLE

The "Great" Magnetic

The following nineteen magnetic storms comprise *all* the storms since the end of 1874 of arc. The table therefore includes *all* the most violent storms in the last twenty-nine

Ref. No.	Magnetic Storm. Period of Disturbance. Greenwich Civil Time. From			To			Duration.	Character of Beginning.	Extreme Amplitude of Movement. Dec.	H.F.	V.F.	Largest Group of No. of Group.	Time of Transit across C.M.		
		d	h		d	h	h		′					d	h
1	1880 Aug.	12	12	Aug.	14	8	44	Sharp	65	·016	·008	343/5	Aug.	13	23
2	1881 Jan.	31	12	Feb.	1	3	15	,,	75	18	8	412	Jan.	30	10
3	Sept.	12	12	Sept.	14	2	38	,,	60	17	8	566	Sept.	10	0
4	1882 Apr.	16	23	Apr.	17	23	24	,,	60 +	30 +	22 +	726	Apr.	17	0
5		20	3		21	8	29	,,	70 +	20 +	8	729		19	3
6	Oct.	2	10	Oct.	3	3	17	,,	60	14	No regis.	846	Sept.	30	14
7	Nov.	17	10	Nov.	21	4	90	,,	110	50 +	·025	885	Nov.	18	20
8	1886 Mar.	30	8	Apr.	1	3	43	,,	65	20 +	7	1860	Mar.	30	20
9	1892 Feb.	13	5	Feb.	14	18	37	,,	70 +	29 +	15 +	2421	Feb.	11	22
10	Mar.	11	22½	Mar.	13	5	30	,,	75	26	6 ±	2440	Mar.	10	15
11	May	18	8	May	19	8	24	,,	73	16	11	2515	May	16	18
12	July	16	12½	July	17	20	32	,,	75	36 +	7 +	2583	July	14	2
13	Aug.	12	12	Aug.	13	2	14	,,	65	34	12	2615	Aug.	11	12
14	1894 Feb.	22	22	Feb.	26	1	75	,,	55	21	7 +	3412	Feb.	22	11
15	July	20	6	July	21	2	20	,,	60	36	14	3624	July	17	4
16	Aug.	20	2½	Aug.	20	18	15	,,	65	22 +	12 +	3668	Aug.	17	5
17	1898 Mar.	15	1	Mar.	16	8	31	,,	75	18 +	10 +	4702	Mar.	11	11
18	Sept.	9	14	Sept.	10	11	21	Grad.	55	20 +	10	4781	Sept.	9	6
19	1903 Oct.	31	6	Nov.	1	5	23	Sharp	121	64	32	...	Oct.	31	21

Mean

Of these nineteen storms—

7	synchronised	with	one of the nineteen greatest spots.
1	,,	,,	the return of one of the nineteen greatest spots.
9	,,	,,	a "large" group of spots.
2	,,	,,	the return of a "large" group of spots.
19			

A group with a projected area of $\frac{1}{1000}$th of the visible disc of the Sun is ranked as "large."

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I.

Storms, 1875–1903.

in which the extreme amplitude of movement in declination has amounted to one degree
years.

Spots on the Sun (Projected Area).							Entire Disc.			
Interval between Storm and Transit.	Date and Place on Disc when*		Mean Coord. of Group.		Area of Group on Day of Storm.		Total Projected Area.	Total Corrected Area.	Proportion to Mean for Year.	No. of Spots on Sun.
d h	First seen	Last seen	Long. °	Lat. °	Projected.	Corrected.				
−1 11	July 20 D	Sept. 18 W	235·0	+24·5	1191	708	1850	1388	3·3	3
+1 2	Jan. 29 D	Feb. 27 D	165·8	−13·0	1083	581	1544	1097	1·5	5
+2 12	Sept. 6 D	Oct. 5 D	100·7	+13·6	1238	777	2332	1770	2·4	7
−0 1	Mar. 23 D	May 10 D	93·0	−19·3	1693	880	6750	4667	4·6	8
+1 0	Apr. 13 E	May 24 W	64·8	−28·5	3343	1908	6809	4314	4·3	7
+1 20	Sept. 25 E	Dec. 1 W	50·2	−21·7	1647	1046	3561	2101	2·1	6
−1 10	Oct. 20 D	Dec. 20 D	120·7	+19·2	4194	2352	4640	2771	2·7	6
−0 14	Mar. 26 E	May 3 W	116·0	−16·8	1008	518	1641	1028	2·7	5
+1 7	Nov. 15 E	Mar. 17 W	255·7	−28·3	5252	2999	7137	4905	4·0	6
+1 8	Nov. 15 E	Mar. 17 W	250·3	−28·4	1111	602	1313	793	0·7	4
+1 14	Apr. 17 D	May 22 W	84·3	−14·0	1055	589	1503	1195	1·0	5
+2 10	June 13 D	Aug. 16 D	33·1	−31·3	1031	728	1674	1546	1·3	4
+1 0	June 13 D	Aug. 16 D	16·5	−30·4	337	214	1394	942	0·8	7
+0 11	Jan. 25 D	Mar. 1 W	186·9	−32·0	2263	1275	3416	1941	1·5	7
+3 2	June 14 E	Aug. 19 W	76·6	−12·4	700	488	2790	1793	1·4	8
+2 21	Aug. 11 E	Sept. 14 D	26·4	+ 6·4	1773	1239	2148	1466	1·1	9
+3 14	Mar. 6 E	May 1 D	119·5	−13·2	1514	1256	1974	1559	4·1	4
+0 8	Sept. 3 E	Nov. 6 D	239·0	−12·1	3742	2011	3759	2021	5·4	3
−0 15	...	...	298·0	−22·0	1216	670	1737	1368	...	2
+1 1										

Of these nineteen storms—

5 took place with two "large" groups on the disc.
3 " " a "large" group east of the C.M.
11 " " a "large" group west of the C.M.
——
19

Taking the mean "Interval between Storm and Transit" for the 14 cases where there was only one "large" group, the result is $+1^{d}\ 2^{h}$, corresponding to a position of 14°·3 west of the C.M.

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* D means that the spot formed or dissipated on the disc, *i.e.* in the visible hemisphere; E, that it was first seen at the east limb; W, that it was last seen at the west limb.

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TABLE

The Nineteen Largest

These include *all* the groups of which the projected area exceeded on any day the area exceeded the 500th part of the visible

No. of Group.	Limiting Dates. From	Limiting Dates. To	No. of Appearance.	Total Duration of Group. Rotation.	Total Duration of Group. Days.	Means for Apparition. Area.	Means for Apparition. Long.	Means for Apparition. Lat.	Day of Greatest Area. Projected. Day.	Day of Greatest Area. Projected. Area.	Day of Greatest Area. Corrected. Day.	Day of Greatest Area. Corrected. Area.
726	1882 Apr. 10	Apr. 23	2nd	3	49	833	93°·0	−19°·3	Apr. 20	2517	Apr. 21	2258
729	Apr. 13	Apr. 25	1st	2	56 ±	1744	64·8	−28·5	Apr. 18	3693	Apr. 21	2109
885	Nov. 12	Nov. 25	2nd	3	62	1711	120·7	+19·2	Nov. 18	4667	Nov. 18	2425
1062	1883 June 25	July 7	1st	2	53 ±	1353	36·2	+10·5	June 30	3573	June 30	1876
1080	July 19	July 31	3rd	4	80	1321	73·9	− 9·5	July 25	3115	July 24	1642
1343	1884 Mar. 31	Apr. 7	1st	4	94 ±	1132	19·1	−10·3	Apr. 3	2486	Apr. 6	2246
1706	1885 June 15	June 27	2nd	4	106 ±	1363	241·0	+10·6	June 21	3767	June 21	1917
2293	1891 Aug. 29	Sept. 10	4th	8	185	1212	221·5	+21·8	Sept. 5	2846	Sept. 8	1798
2421	1892 Feb. 5	Feb. 18	4th	5	138 ±	2402	255·7	−28·3	Feb. 11	5359	Feb. 13	2999
2581	July 4	July 16	2nd	5	135 ±	1591	83·2	+11·0	July 10	3994	July 7	2387
3106	1893 Aug. 2	Aug. 13	1st	2	53 ±	1594	292·6	−17·6	Aug. 7	4771	Aug. 7	2621
3281	Nov. 16	Nov. 28	1st	3	74 ±	1234	322·1	− 5·1	Nov. 20	2992	Nov. 20	1686
3412	1894 Feb. 16	Mar. 1	2nd	2	43 ±	1208	186·9	−32·0	Feb. 21	3038	Feb. 21	1742
3668	Aug. 11	Aug. 23	1st	2	42 ±	1246	26·4	+ 6·4	Aug. 16	3741	Aug. 16	1910
3731	Oct. 2	Oct. 14	1st	1	27 ±	1453	59·9	−12·4	Oct. 6	4123	Oct. 5	2511
4428	1896 Sept. 10	Sept. 22	1st	1	27 ±	1731	55·7	+13·1	Sept. 17	4254	Sept. 11	2458
4497	1897 Jan. 3	Jan. 15	1st	3	81 ±	2132	342·8	− 6·9	Jan. 8	5239	Jan. 8	2743
4781	1898 Sept. 3	Sept. 15	2nd	4	82	1556	239·0	−12·1	Sept. 10	4033	Sept. 10	2235
	1903 Oct. 4	Oct. 18	1st	2	56 ±	1700	201·0	−22·0	Oct. 11	3800	Oct. 11	2080

The figures for the spot-group of 1903 October 4–18 are estimated only.

Of the nineteen spot-groups—

7 were in the Northern Hemisphere.
12 „ „ Southern „
—
19

Nine spot-groups had a mean corrected area for the apparition of over 1500 millionths.

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II.

Spot-groups, 1875–1903.

400th part of the visible disc of the Sun—2500 millionths, or of which the corrected hemisphere of the Sun—2000 millionths.

Day of Transit across C.M. Date.	Total Projected.	Area Corrected.	Magnetic Storm. Time of Beginning G. Civil T.	Class.	Duration.	Character of Beginning.	Extreme Amplitude of Movement. Dec.	H.F.	V.F.	Interval between Storm & Transit.
d h			d h		h		′			d h
Apr. 17 0	6750	4667	Apr. 16 23	Great	24	Sharp	60+	·030+	·022+	–0 1
Apr. 19 3	6537	3934	Apr. 20 3	”	29	”	70+	20+	8	+1 0
Nov. 18 20	5422	2937	Nov. 17 10	”	90	”	110	50+	25	–1 10
July 1 13	4111	2229	June 30 5	Moder.	47	Grad.	20	8	2	–1 8
July 25 21	4548	2843	July 30 0	”	84	Sharp	25	8	3	+4 3
Mar. 31 18	614	423	...	None	...	...	...	...	...	...
June 21 12	4483	2328	June 24 22	Active	36	Sharp	30	12	4	+3 10
Sept. 3 15	3432	2172	Sept. 9 10	”	70	”	33	6	5	+5 19
Feb. 11 22	5863	3800	Feb. 13 5	Great	37	”	70+	29+	15+	+1 7
July 10 6	6391	4275	July 12 18	Active	42	”	33	22	6	+2 12
Aug. 7 10	8499	5128	Aug. 6 4	”	44	”	30	15	4	–1 6
Nov. 22 8	3840	2132	...	Minor	...	...	...	...	...	...
Feb. 22 11	4161	2707	Feb. 22 22	Great	75	Sharp	55	21	7+	+0 11
Aug. 17 5	3809	2288	Aug. 20 2½	”	15	”	65	22+	12+	+2 21
Oct. 8 3	4667	2587	...	Minor	...	...	...	...	...	...
Sept. 16 17	4116	2021	Sept. 18 2	Active	22	Grad.	33	14	3	+1 9
Jan. 9 10	4739	2441	Jan. 2 13	”	14	”	39	4	4	–6 21
Sept. 9 6	3759	2021	Sept. 9 14	Great	21	”	55	20+	10	+0 8
Oct. 11 18	4800	2800	Oct. 12 18	Active	10	Sharp	35	...	...	+1 0
										Mean +0 20

Of these 4 were synchronous with "great" storms.
” ” 5 ” ” "active" ”
—
9

Ten spot-groups had a mean corrected area for the apparition of over 800 millionths and less than 1500 millionths.

Of these 3 were synchronous with "great" disturbances.
” ” 2 ” ” ” "active" ”
” ” 2 ” ” ” "moderate" ”
” ” 2 ” ” ” "minor" ”
” ” 1 ” ” ” no disturbance.
—
10

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Storm No. 1, 1880 *August* 12–14.—Preceded by disturbance from August 11^{d} 12^{h}–August 12^{d} 6^{h}. Extreme amplitude in Dec. = 23′. Followed by very quiet period.

Sun-spots on 1880 *August* 12^{d}·485.

No. of Group.	Total Area. Projected.	Total Area. Corrected.	Heliographic Longitude.	Heliographic Latitude.	Long. from C.M.
342	321	459	324°·2	+12°·5	+70°·4
343	795	444	234·5	+24·6	−19·3
344	211	131	225·6	−16·9	−28·2
345	396	264	213·5	+21·0	−40·3
346	127	90	216·0	−18·9	−37·8
Totals	1850	1388			

These five groups should probably be reckoned as three, since in the following rotation Nos. 343 and 345 form one almost continuous stream, and 344 and 346 another.

There were thus two important groups on the Sun at the time of the storm :—

Nos. 343–345, with total projected area 1191 and total corrected 708. This was its greatest appearance. It formed on the disc July 20, and was last seen at the west limb September 18.

Nos. 344–346, with total projected area 338, and total corrected 221. In the next rotation it was six times as large ; a very great group, with a mean corrected area for the time of appearance, September 4–16, of 1314. It was first seen, at the east limb, August 9, and last seen, at the west limb, October 14.

Storm No. 2, 1881 *January* 31–*February* 1.—Preceded by a moderate movement from January 30^{d} 23^{h}–January 31^{d} 7^{h}. Extreme amplitude in Dec. = 16′. Followed by very quiet period.

Sun-spots on 1881 *January* 31^{d}·452.

No. of Group.	Total Area. Projected.	Total Area. Corrected.	Heliographic Longitude.	Heliographic Latitude.	Long. from C.M.
411	202	360	168°·8	+15°·2	+22°·6
412	1083	581	165·9	−12·9	+19·7
413	96	56	116·2	−16·6	−30·0
414	13	8	107·1	−14·5	−39·1
415	150	92	70·5	+18·8	−75·7
Totals	1544	1097			

Only one of these groups was seen during any other rotation.

No. 412 formed on the disc on January 29 ; passed off at the west limb, February 4 ; reappeared, east limb, on February 20 ; disappeared on the disc, February 27. January 31 was the day of its greatest area. Its rise, therefore, was very rapid.

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Storm No. 3, 1881 *September* 12–14.—Preceded by two moderate movements, one from September $8^{d}\ 22^{h}$ to September $9^{d}\ 3^{h}$; extreme amplitude in Dec. = 15′; the other from September $9^{d}\ 21^{h}$–September $10^{d}\ 3^{h}$; extreme amplitude in Dec. = 14′. Followed by an active movement, September $14^{d}\ 13^{h}$–September $15^{d}\ 1^{h}$; extreme amplitude in Dec. = 30′.

Sun-spots on 1881 *September* $13^{d}{\cdot}583$.

No. of Group.	Total Area. Projected.	Total Area. Corrected.	Heliographic Longitude.	Heliographic Latitude.	Long. from C.M.
			°	°	°
566	1238	777	101·6	+13·7	+49·4
568	342	216	88·4	− 3·3	+36·2
569	23	13	27·4	+17·2	−24·8
570	51	30	21·5	+19·6	−30·7
571	228	224	351·9	+17·0	−60·3
572	421	473	348·0	+22·1	−64·2
573	29	37	344·2	+17·8	−68·0
Totals	2332	1770			

Of these groups none were seen in the previous rotation, and only two in the following, viz. Nos. 566 and 572. No. 566 formed on the disc, September 6, and disappeared likewise on the disc, October 5. No. 572 was not nearly so large a group as No. 566, and was first seen, September 12, at the east limb, disappearing on the disc, October 14.

Storms Nos. 4 and 5, 1882 *April* 17 and *April* 20–21. These two storms occurred in a disturbed period. Its history is as follows:—

April $13^{d}\ 23^{h}$–$14^{d}\ 7^{h}$. Fluctuations in Dec. (±3′), with wave at commencement (−10′), and wave at $14^{d}\ 4^{h}$ (+10′).

April $14^{d}\ 12^{h}$–$15^{d}\ 1^{h}$. Fluctuations in Dec. (±3′) with wave at $18\frac{1}{4}^{h}$ (−8′).

April $15^{d}\ 23^{h}$–$16^{d}\ 4^{h}$. Fluctuations in Dec. (±3′).

April $16^{d}\ 13\frac{1}{2}^{h}$–$19^{h}$. Fluctuations in H.F. (±·0015).

April $16^{d}\ 23\frac{1}{2}^{h}$. Storm No. 4 begins.

April $17^{d}\ 23^{h}$. Storm No. 4 ends.

April $18^{d}\ 20\frac{1}{4}^{h}$. Sharp wave in Dec. (−6′).

April $20^{d}\ 3^{h}$. Storm No. 5 begins. Oscillations sometimes 14 or 15 an hour.

April $20^{d}\ 12^{h}$. Very rapid oscillations end.

April $21^{d}\ 8^{h}$. Storm No. 5 ends.

April $21^{d}\ 22^{h}$. Wave in Dec. (+8′).

April $23^{d}\ 20\frac{1}{2}^{h}$–$24^{d}\ 9^{h}$. Fluctuations in Dec. (±5′).

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Sun-spots on 1882 *April* $17^{\mathrm{d}}\cdot587$.

No. of Group.	Total Area. Projected.	Total Area. Corrected.	Heliographic Longitude.	Heliographic Latitude.	Long. from C.M.
722	115	285	160°·3	+21°·1	+75°·2
728	970	940	144·0	−17·8	+58·9
726	1693	880	92·5	−18·3	+ 7·4
732	35	19	72·2	−21·9	−12·9
729	3388	1963	65·3	−28·7	−19·8
733	317	177	60·4	−13·8	−24·7
734	160	200	20·6	+10·9	−64·5
735	72	203	4·4	−11·6	−80·7
Totals	6750	4667			

Sun-spots on 1882 *April* $21^{\mathrm{d}}\cdot409$.

No. of Group.	Total Area. Projected.	Total Area. Corrected.	Heliographic Longitude.	Heliographic Latitude.	Long. from C.M.
731	28	70	113°·9	−18°·7	+79°·3
726	2402	2258	92·3	−17·5	+57·7
729	3396	2109	64·0	−28·7	+29·4
733	221	125	62·2	−13·2	+27·6
734	444	237	22·7	+11·4	−11·9
735	339	193	6·6	−10·2	−28·0
738	68	124	321·3	+ 7·1	−73·3
Totals	6898	5116			

Only three of these groups were considerable.

No. 726 was seen in the preceding and also in the following rotation. It formed and dissipated in the visible hemisphere, being first seen March 23, and last seen May 10. It appeared at the east limb April 10, and underwent a sudden and great development on April 17, increasing from an area of 156 on April 16 to an area of 1371 on April 18. This was synchronous with Storm No. 4.

No. 729 came on at the east limb on April 13 with the first slight fluctuations of the magnetic needle, and passed the C.M. on April 19. It passed off at the west limb on April 25, returned in the next rotation, and was last seen at the west limb, May 24.

No. 728 developed from an area of 769 on April 16 to an area of 940 on April 17, and diminished afterwards. This increase seems to have been coincident with the much greater increase of No. 726. It was first seen, April 11, on the disc, and last seen, May 5, also on the disc.

All three groups were at their greatest development during the present apparition.

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Storm No. 6, 1882 *October* 2–3.—Preceded by a quiet time. Followed by fluctuations, October 4^d 16^h–23^h, in Dec. (±5′), and by an "active" disturbance, October 5^d 18^h–October 6^d 16^h (Dec. ±16′). Fluctuations in Dec. (±5′) from October 8^d $19\frac{1}{2}^h$ to October 9^d 1^h and October 9^d $19\frac{1}{2}^h$ to October 10^d 2^h. October 10^d $18\frac{1}{4}^h$–$20\frac{1}{2}^h$; wave in Dec. (−20′).

Sun-spots on 1882 *October* 2^d·560.

No. of Group.	Total Area. Projected.	Corrected.	Heliographic Longitude.	Latitude.	Long. from C.M.
845	16	11	66°·3	+21°·0	+42°·1
846	1647	1046	50·0	−21·7	+25·8
847	119	64	40·4	+20·3	+16·2
848	911	534	34·6	−22·9	+10·4
849	823	418	32·7	+ 8·0	+ 8·5
850	45	28	348·3	+ 6·6	−35·9
Totals	3561	2101			

Three of the groups were considerable, and two of them, Nos. 846 and 848, were in the same latitude, and only about 12° apart in longitude. These, therefore, probably formed only a single disturbance. In the following rotation the two groups appear to have coalesced. This double group, 846+848, was by far the most important visible on October 2. It was seen during three rotations, being first seen, September 25, at the east limb, and last seen, December 1, at the west limb. It attained its greatest area during the present apparition.

Storm No. 7, 1882 *November* 17–21.—A very long-continued disturbance, beginning about November 11^d 21^h and lasting until November 26^d 22^h. Characteristic sharp swings occurred November 14^d 14^h, November 15^d 8^h, November 16^d 8^h, November 17^d 10^h, November 19^d 13^h, November 25^d $16\frac{1}{2}^h$. The great storm lasted November 17^d 10^h–November 21^d 4^h; but from November 11^d 21^h–November 13^d 23^h was an "active" disturbance, of extreme amplitude 50′ in Dec. Two other "active" disturbances followed, the one November 21^d 16^h–24^h; amplitude 40′ in Dec.; the other November 25^d $16\frac{1}{2}^h$–November 26^d 3^h; amplitude 37′.

Sun-spots on 1882 *November* 17^d·277.

No. of Group.	Total Area. Projected.	Corrected.	Heliographic Longitude.	Latitude.	Long. from C.M.
877	42	100	216°·9	−24°·4	+75°·6
887	56	35	173·3	+19·2	+32·0
884	86	44	148·1	− 7·8	+ 6·8
885	4194	2352	120·1	+19·1	−21·2
888	124	104	88·5	− 6·3	−52·8
889	137	136	81·5	+10·9	−59·8
Totals	4639	2771			

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There was only one considerable group, and that one, No. 885, was the largest in the whole cycle, 1878 to 1889, as Storm No. 7 was the most violent magnetic storm in the same period.

This group formed on the disc, October 20; passed off at the west limb, October 28; returned to the east limb, November 12; passed off at the west limb, November 25; returned to the east limb, December 10; disappeared on the disc, December 20. Its mean area during the apparition November 12–25, the period of its greatest development, was 1711.

Storm No. 8, 1886 March 30 to April 1.—Preceding the storm there was a double wave in Dec. $(+8'$ to $-8')$, March $29^{d}\ 0\frac{3}{4}^{h}$–$3\frac{1}{2}^{h}$. There were also fluctuations of about $\pm 3'$ in Dec. every day from March 15 to March 28.

The storm was followed by fluctuations in Dec. $(\pm 4')$, April $1^{d}\ 6^{h}$–11^{h}, and a wave $(-10')$ $18\frac{1}{2}^{h}$–19^{h}.

The storm itself was divided into two short but sharp disturbances, the one March $30^{d}\ 8^{h}$–March $31^{d}\ 5^{h}$, the other March $31^{d}\ 11^{h}$–April $1^{d}\ 3^{h}$. In both the oscillations attained a frequency of 20 per hour.

Sun-spots on 1886 *March* $30^{d}\cdot232$.

No. of Group.	Total Area. Projected.	Total Area. Corrected.	Heliographic Longitude.	Heliographic Latitude.	Long. from C.M.
1856	57	172	200°·2	+ 5°·5	+76°·3
1859	525	273	136·5	− 1·2	+ 12·6
1860	1008	518	115·3	−16·8	− 8·6
1861	34	47	53·7	−11·9	−70·2
1862	14	18	56·1	− 8·7	−67·8
Totals	1638	1028			

Three of these groups were seen in other rotations, viz. Nos. 1856, 1859, and 1860. Of these, Group No. 1860 was the most considerable. It was first seen, March 26, at the east limb, and last seen, May 3, at the west limb. Its mean area during the present apparition, in which it attained its greatest development, was 487.

Storm No. 9, 1892 February 13–14.—Preceded by small daily fluctuations $(\pm 3')$, with occasional waves of 7′ to 10′ in Dec. from January 28 to February 12.

Followed by a moderate disturbance (17′) February $15^{d}\ 13^{h}$–24^{h}; and by small daily fluctuations until February $20^{d}\ 18^{h}$–February $21^{d}\ 4^{h}$, when another moderate disturbance took place (24′). This began with a characteristic sharp movement.

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Sun-spots on 1892 *February* $13^{d}\cdot408$.

No. of Group.	Total Area. Projected.	Total Area. Corrected.	Heliographic Longitude.	Heliographic Latitude.	Long. from C.M.
2421	5252	2999	255°·4	−28°·6	+19°·6
2425	1023	529	239·5	−19·4	+ 3·7
2426	134	100	193·2	+15·9	−42·6
2427	203	191	180·2	+ 9·6	−55·6
2428	273	374	169·5	+12·8	−66·3
2429	253	712	158·4	+15·4	−77·4
Totals	7138	4905			

Of these six groups No. 2421 was much the largest. It was first seen on the east limb on 1891 November 15. The present appearance was therefore during its fourth rotation. It appeared on the east limb on February 5, passed off at the west limb on February 18, and its mean area for the apparition was 2402, the largest group in the eleven-year cycle 1879–1901.

Storm No. 10, 1892 March 11–13.—A long-continued but not very intense disturbance preceded the storm. It commenced February $29^{d}\ 21^{h}$ and continued until March $9^{d}\ 5^{h}$. Extreme amplitude 45′ in Dec.

After the storm there were fluctuations in Dec. (±3′) March $15^{d}\ 20^{h}$–March $16^{d}\ 3^{h}$, with wave (−15′) March $15^{d}\ 22^{h}$–$16^{d}\ 0\frac{1}{2}^{h}$.

Sun-spots on 1892 *March* $11^{d}\cdot152$.

No. of Group.	Total Area. Projected.	Total Area. Corrected.	Heliographic Longitude.	Heliographic Latitude.	Long. from C.M.
2443	68	36	260°·6	−15°·7	+17°·0
2440	1111	602	250·5	−28·5	+ 6·9
2442	103	110	181·1	−23·4	−62·5
2444	31	45	173·0	−26·0	−70·6
Totals	1313	793			

The only important group was No. 2440, the return of group No. 2421, the premier group of the cycle. No. 2440 was seen on the east limb, March 4, and reached the west limb, March 17. Its mean area was 386. It did not return.

Storm No. 11, 1892 May 18–19.—Preceded by moderate fluctuations and waves from May $16^{d}\ 22^{h}$–May $17^{d}\ 24^{h}$. Extreme amplitude in Dec. 20′. Followed by small sharp movements from May $19^{d}\ 15^{h}$–May $20^{d}\ 8^{h}$ (±3′).

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Sun-spots on 1892 *May* 18^{d}·439.

No. of Group.	Total Area. Projected.	Total Area. Corrected.	Heliographic Longitude.	Heliographic Latitude.	Long. from C.M.
			°	°	°
2515	1055	589	84·4	−14·2	+22·6
2519	284	149	50·4	+10·0	−11·4
2522	14	7	41·9	+6·2	−19·9
2523	4	4	7·1	−25·5	−54·7
2524	147	446	342·1	+14·9	+79·7
Totals	1504	1195			

Three of these were considerable groups.

Group No. 2515 was the largest of the three, with a mean area of 742 for the rotation, and had passed the central meridian about a day and a half at the time of the storm. No. 2524 was actually on the east limb at the time. No. 2519, the smallest of the three, was one day short of reaching the central meridian.

No. 2515 formed on the disc, April 17; made its second appearance, May 10, at the east limb; and disappeared, May 22, at the west limb. No. 2519 appeared first at the east limb, May 14, and disappeared on the disc, June 17. No. 2524 formed on the disc, April 23, and was last seen, June 26, at the west limb.

Storm No. 12, 1892 *July* 16–17.—Preceded by "active" disturbances: one from July 12^{d} 18^{h}–July 13^{h} 12^{d}, the other from July 13^{d} 18^{h}–July 14^{d} 11^{h}. Followed by small rapid fluctuations in Dec. July 21^{d} 0^{h}–8^{h}, with wave $2\frac{1}{2}^{h}$–$4\frac{1}{2}^{h}$ (+20′).

Sun-spots on 1892 *July* 16^{d}·240.

No. of Group.	Total Area. Projected.	Total Area. Corrected.	Heliographic Longitude.	Heliographic Latitude.	Long. from C.M.
			°	°	°
2581	177	393	81·1	+10·4	+77·5
2583	1031	728	31·7	−31·3	+28·1
2584	183	108	25·7	+28·4	+22·1
2586	283	317	301·6	−9·5	−62·0
Totals	1674	1546			

All four groups were considerable, and all were seen during more than one rotation.

Of the four groups No. 2581 was much the largest and longest lived, but it was passing off at the west limb when the storm began. It attained its greatest area, 1591, during this apparition.

No. 2583 was the second in size, and was at its largest during this apparition. Mean area 829.

It seems doubtful which group should be associated with the spot, probably No. 2583. The groups were first seen:—No. 2581, June 7, east limb; No. 2583, June 13, on disc; No. 2584, June 12, on disc; and No. 2586, July 15, east limb. They were

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last seen :—No. 2581, Oct. 5, west limb ; No. 2583, August 16, on disc ; No. 2584, July 20, west limb ; and No. 2586, August 22, west limb.

Storm No. 13, 1892 *August* 12–13.—Preceded by two "moderate" disturbances, viz. August 3^d 14^h–23^h, and August 4^d $14\frac{1}{2}^h$–August 5^d 1^h. A quiet period followed the storm.

Sun-spots on 1892 *Aug.* 12^d·280.

No. of Group.	Total Area.		Heliographic		Long. from C.M.
	Projected.	Corrected.	Longitude.	Latitude.	
			°	°	°
2615	337	214	15·4	−30·5	+ 9·4
2620	144	73	11·4	+14·5	+ 5·4
2621	212	112	13·7	+25·0	+ 7·7
2617	127	66	11·3	− 8·4	+ 5·3
2618	106	57	354·0	−14·2	−12·0
2622	367	299	313·3	+10·4	−52·7
2623	104	121	302·8	− 7·4	−63·2
Totals	1397	942			

None of the groups were large, but two were returns of groups seen on the disc during Storm No. 12, viz. No. 2615, a return of No. 2583 ; and No. 2623, a return of No. 2586. This is important, as it renders it probable that the other two groups seen during Storm No. 12, viz. Nos. 2581 and 2584, were not connected with that disturbance. The group No. 2615, the return of No. 2583, appears the most likely group on this occasion. Its mean area during the rotation when it attained its greatest development was 829 millionths, July 7–19 ; whilst No. 2622, the next most important group, was only 426 during the rotation Sept. 7–18.

Storm No. 14, 1894 *February* 22–26.—Preceded by "active" disturbance, amplitude 36′ in Dec., beginning with characteristic sharp movement at February 20^d $20\frac{1}{2}^h$ and lasting till February 22^d 6^h. Followed by "active" disturbance, amplitude 50′ in Dec., beginning with characteristic sharp movement at February 28^d 15^h, and lasting till March 1^d 3^h. Minor fluctuations followed till March 2^d 20^h.

Sun-spots on 1894 *February* 23^d·210.

No. of Group.	Total Area.		Heliographic		Long. from C.M.
	Projected.	Corrected.	Longitude.	Latitude.	
			°	°	°
3408	94	53	200·3	−26·4	+21·8
3418	2	1	193·5	−27·7	+15·0
3412	2263	1275	187·5	−31·8	+ 9·0
3420	241	123	174·5	−15·7	− 4·0
3413	366	214	152·7	−25·8	−25·8
3416	155	90	151·0	+ 3·7	−27·5
3417	295	185	142·1	−16·1	−36·4
Totals	3416	1941			

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Group No. 3412 was the only large one. It formed on the disc, January 25, passed off at the west limb, January 29; reappeared at the east limb, February 16; and passed off at the west limb, March 1. It did not return again. Mean area during the present rotation 1208, its greatest development.

Storm No. 15, 1894 *July* 20–21. Preceded and followed merely by the small fluctuations common throughout the year.

Sun-spots on 1894 *July* 20ᵈ·176.

No. of Group.	Total Area. Projected.	Corrected.	Heliographic Longitude.	Latitude.	Long. from C.M.
3624	700	488	77°·0	−12°·5	+40°·5
3628	25	14	64·6	−11·5	+28·1
3629	559	299	57·3	+ 6·9	+20·8
3630	542	298	53·7	−11·2	+17·2
3635	14	7	44·5	−16·6	+ 8·0
3637	542	351	357·3	+12·8	−39·2
3638	403	326	344·7	+14·7	−51·8
3640	5	10	320·5	−10·1	−76·0
Totals	2790	1793			

Groups No. 3624 and No. 3637 were the largest and longest lived, both having passed their greatest area during an earlier rotation. Of the two No. 3624 was not only the larger now, but was much the larger at greatest development, and was now in an earlier phase of its decline. It was first seen, June 14, at the east limb, and last seen, August 19, at the west limb. It attained its greatest area during the previous apparition, 1894 June 14–25.

Storm No. 16, 1894 *August* 20.—Preceded and followed merely by the small fluctuations common throughout the year.

Sun-spots on 1894 *August* 20ᵈ·398.

No. of Group.	Total Area. Projected.	Corrected.	Heliographic Longitude.	Latitude.	Longitude from C.M.
3681	5	5	41°·7	+ 5°·2	+58°·1
3668	1773	1239	28·4	+ 6·9	+44·8
3682	6	4	19·1	−17·6	+35·5
3683	17	8	349·8	+ 7·1	+ 6·2
3672	24	13	346·9	−19·3	+ 3·3
3674	162	83	336·3	− 5·8	− 7·3
3675	25	17	321·0	−26·7	−22·6
3678	29	21	299·7	−12·5	−43·9
3679	106	76	297·7	+17·8	−45·9
Totals	2147	1466			

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Only three of these were considerable or long-lived—viz. Nos. 3668, 3674, and 3679; and of these Group No. 3668 was by far the most important. It was first seen, August 11, at the east limb, and last seen, September 14, on the disc. It attained its greatest area during the present apparition, 1894 August 11–23.

Storm No. 17, 1898 *March* 15–16.—Preceded by an "active" disturbance, March 11^{d} 14^{h}–March 12^{d} 6^{h}; amplitude in Dec. = 30′. The movements, however, were slow and not numerous.

The maximum range of movement in the storm itself was over 60′, thus ranking it as a "great" storm; but the storm was not a violent one in other characteristics, the oscillations being comparatively few and slow. Only the fluctuations ordinary to the year followed.

Sun-spots on 1898 *March* $15^{d}\cdot372$.

No. of Group.	Total Area. Projected.	Total Area. Corrected.	Heliographic Longitude.	Heliographic Latitude.	Longitude from C.M.
			°	°	°
4702	1514	1256	122·7	−13·3	+53·2
4703	131	102	116·3	+11·0	+46·8
4704	322	197	104·4	− 8·2	+34·9
4706	7	4	94·2	− 3·7	+24·7
Totals	1974	1559			

Of these groups No. 4702 was much the largest. No. 4706 was very small and short-lived, and the other two groups were only about one-fourth or one-fifth the area of No. 4702, even when they were largest. Group No. 4702 was first seen, March 6, at the east limb, and last seen, May 1, on the disc. It attained its greatest area during the present apparition, 1898 March 6–17.

Storm No. 18, 1898 *September* 9–10.—Preceded by two successive waves in Dec. (−7′ and −6′) on September 8^{d} 16^{h}–20^{h}.

The storm scarcely amounted to a "great" one. The extreme amplitude in Dec. was not quite a degree, and the oscillations were not very frequent.

Followed by movements lasting until September 11^{d} 12^{h}, about 18′ in Dec.

Sun-spots on 1898 *September* $9^{d}\cdot624$.

No. of Group.	Total Area. Projected.	Total Area. Corrected.	Heliographic Longitude.	Heliographic Latitude.	Longitude from C.M.
			°	°	°
4782	10	6	248·4	− 7·2	+15·3
4781	3742	2011	238·1	−11·7	+ 5·0
4783	7	4	230·9	−18·4	− 2·2
Totals	3759	2021			

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The only important group was No. 4781, the other two being very small and seen only on the one day.

No. 4781 was seen during three rotations—viz. September 3–15, September 30–October 12, and October 28–November 6. Its first appearance was at the east limb on September 3; its last appearance, on the disc, on November 6. It attained its greatest area during the present apparition, 1898 September 3–15.

Storm No. 19, 1903 *October* 31–November 1.—Preceded by a wave in Dec. and H.F. at October 30^{d} 21^{h}, and then by small movements up to the time of the characteristic instantaneous movement.

Sun-spots on 1903 *October* 31^{d}·426.

Letter for Group.	Total Area. Projected.	Corrected.	Heliographic Longitude.	Latitude.	Longitude from C.M.
a.	1216	670	296°·0	−20°·0	− 5°·8
b.	520	698	232·0	+17·5	−69·8
Totals	1736	1368			

Group *a* appeared at the east limb on October 25, and reached the west limb November 6. The measures for October 31 are approximate only; not definitive.

Further Note on the "Great" Magnetic Storms, 1875–1903, *and their association with Sun-spots.* By E. Walter Maunder.

The facts brought out in the preceding paper are, so far as they go, in entire agreement with the facts tabulated in the important paper by the Rev. W. Sidgreaves read before the Society 1900 December 14. The difficulty is in their interpretation. It has been urged that if there be a real direct connexion between a particular great sun-spot and a great magnetic storm, then that connexion should always show itself. Every great spot on the Sun should be answered by a great magnetic storm here; every great magnetic storm should be synchronous with the appearance of some great spot; and, further, the violence of the storm should bear a definite relation to the extent of the spot. This relation does indeed hold good if we consider only the average of a number of instances; it does not hold good universally in every individual case.

An example is in the immediate recollection of everyone. The sun-spot which crossed the central meridian on 1903 October 12 was one of the six or seven largest groups seen during thirty years. The magnetic storm which occurred at this